

Climate Change Adaptation in the Gulf Coast/SE Energy Sector:

Understanding vulnerability, adaptation, and perception of key uncertainties

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Overview:



- The Regional Integrated Assessment Modeling (RIAM) (All Operated by Battelle Since 19 project:
 - Multi-year effort for DOE to improve regional integrated assessment and Earth system modeling capabilities through application to the Gulf Coast region of the US
 - Stakeholder work to ground experiments
- ▶ Today:
 - Why study energy sector adaptation? Purpose/scope/goals
 - Description of stakeholder research process/results
 - Scope/questions/methods
 - Typology
 - Stakeholder interviews
 - Preliminary findings
 - Insights for adaptation science

Purpose-Scope:



Identify key vulnerabilities, adaptation alternatives, and perception of keywilly Operated by Bathelle Since 1965 uncertainties within the Gulf Coast energy sector (oil, gas, and electric sectors) with respect to the risk of extreme storms, coastal inundation, increased air and water temperatures, and reduced water availability in the region



LNG Terminal Pascagoula, MI 2011

- Provide basis for understanding actual adaptation alternatives for use in future experiments as well as identifying key stakeholders for future work
- Identify additional data sources of use in experiments (looping stakeholder insights back into modeling efforts when possible)
- Contribute to adaptation science

Goals for Stakeholder Research



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- Develop specific information on vulnerabilities and adaptation alternatives in the region for use in future modeling efforts
 - What are the impacts/vulnerabilities for the sector (oil, gas, electric)?
 - How are the impacts/vulnerabilities distributed within the SE/GC (10 state) region?
 - What adaptation alternatives (to high air and water temperatures, flooding, extreme events, water availability issues) are being considered?
 - What are the issues/decision criteria for energy sector stakeholders?
- Informational gap analysis:
 - From peer-reviewed literature: what issues might not be under consideration by the energy sector that should be? (decision typology)
 - From energy sector stakeholders: what issues are under discussion/considered important by energy sector professionals that have been overlooked in the literature (i.e., what does the industry know that the academic community does not know?) (interviews)

RIAM Adaptation Typology



- Decision typology to capture and organize information emerging from by Bathele Since 1965 the literature review and stakeholder interviews
 - Captures 'vital statistics' of decision makers and other stakeholders
 - Sectoral/operational context
 - Impacts, vulnerabilities, adaptation alternatives
 - Decision processes
 - Decision criteria
 - Key uncertainties
 - Database implementation identifies decision making patterns
 - FMP (& possibly Nvivo)



RIAM Adaptation Typology

 Decision typology to capture and organize information emerging from the literature review and stakeholder interviews

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High-level field structure of FMP database					
Author/Stakeholder	Date, knowledge source				
Region Information	GC, non-GC SE, state specific, relevant RIAM analysis (air/water temp, storm surge, wind, off-shore, electricity demand, siting of new gen infrastructure, other)				
Hazards Addressed	Air temperature, water temperature, water availability				
Sector Information	Electricity supply, oil and gas supply, transmission-distribution, end-use				
Types of Impacts	Impacts to infrastructure, generation capacity, consumers, indirect, other vulnerabilities				
Adaptations Identified, Under Consideration, or Implemented	No adaptation, protect infrastructure, modify operations, enhance supply, manage demand, modify emergency response, capacity building				
Adaptation Decision Process- Comparing and Selecting Alternatives	Analysis methods, decision criteria, key uncertainties, organizational process				

RIAM Adaptation Typology



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Sector Information (choose General only if specific sector info not available)	
Sector_Electricity_Supply	
Sector_Oil_Gas_Supply General Oil Extraction Oil Refining Gas Extraction X NA	
Sector_Transm_Dist General Electricity Grid Oil Pipeline Gas Pipeline NA	
Sector_End_Use X General Residential Commercial Industrial Transport NA	
Sector_Comments	
Types of Impacts Impacts_Infrastructure Damage to power plants Damage to offshore oil & gas facilities Damage to oil refining facilities Damage to electricity transmission lines Damage to oil & gas pipelines X NA Other Impacts_Generation Capacity Demand Supply NA Other Impacts_Consumers Demand Supply NA Other Indirect_Impacts Impacts on human capital (e.g., staff) Damage to transportation networks (e.g., roads, ports) Damage to ecological systems (e.g., oil spills) Damage to company repuation NA Other	Other_Vulnerabilities Vulnerable location Growth in consumer demand (e.g., population growth) Disuption of response and recovery Lack of adequate information Depreciation/Aging of infrastructure Regulatory/policy constraints or complexity Financial constraints (e.g., available capital, energy prices) NA Other

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Stakeholder selection: **Pacific Northwest** NATIONAL LABORATORY Proudly Operated by Battelle Since 1965 **Industry Scales Generation companies** Exploration Supply al Regulators Extraction Investment **Generation facilities** •Power plant operations (fossil, coal, nuclear) Refinery operations •Solar, wind, biomass operations Fed Wholesale transmission services **Climate** High-voltage transmission (electricity) Change •Oil & gas pipelines •Biomass & biofuel transportation **Transmission/** Distribution ulators **Retail distribution services** Low-voltage distribution (electricity) •End user sales (petroleum) State Re **Individual consumers** Industrial **Demand** Commercial Residential

Stakeholder selection:



Regional distribution/coverage

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126202 Tennessee Valley Authority 31,451 26,490 7,167 16,285 0 2,987 0 0 0 0 51 101272 Florida Power & Light Co. 25,219 7 25,184 5,188 0 0 0 14,478 0 237 0 0 0 100959 Georgia Power Co. 19,018 7 18,277 7,7520 7,993 0 2,553 0 213 0 0 0 0 100959 Georgia Power Co. 19,018 7 18,144 0 14,571 0 1,231 1,377 966 0 0 0 6 2655498177 NNG Texas, LLC 15,339 7 15,339 2,430 7,857 0 1,352 0 0 3,694 0 6 6 2655498177 NNG Texas, LLC 14,800 7 14,800 0 5,675 0 176 1,972 0 6,977 0 0 116650 Carolina Power & Light Co. 13,665 7 13,768 3,732 5,012 0 4,570 0 453 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Turbine	Cycle	on	Internal Combusti on	Natural Gas - Steam Turbine	Oil - Gas Combustio n Turbine	Combined Cycle	Combustion Turbine	Biomass - Steam Turbine	Coal - Steam Turbine		al	erators >	• Ope	pla
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1613055 Luminant Energy Company, LLC 15,339 15,339 2,430 7,857 0 1,352 0 0 3,694 0 6	0	0 0	0	0	0	213	0	2,553	0	7,993	7,520	18,277		9 Duke Energy Carolinas, LLC	100709
2625498177 NRG Texas, LLC	0	0	0	0	0	966	1,377	1,231	0	14,571	0	18,144		9 Georgia Power Co.	100959
116650 Carolina Power & Light Co. 13,965	0	5 0	6	0	3,694	0	0	1,352	0	7,857	2,430	15,339		5 Luminant Energy Company, LLC	14613055
4877913 Calpine Corp. 13,135 13,135 0 0 985 12,150 0 0 0 0 101304 Alabama Power Corp. 11,268 11,168 0 9,312 0 1,288 567 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0	0	0	0	6,977	0	1,972	176	0	5,675	0	14,800		7 NRG Texas, LLC	2625498177
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11706551 Southern Power Co. 7,976	0	0	0	0	0	0	567	1,288	0	9,312	0	11,168		4 Alabama Power Co.	101304
101516 Entergy Arkansas, Inc. 6,674 6,609 0 3,400 0 78 904 0 2,227 0 0 0 104284 (fity Public Service Board of San Antonio 6,449 6,449 0 3,071 0 0 550 0 2,829 0 0 0 10425 Entergy Louisiana, Inc. 6,179 6,179 1,200 0 0 0 0 0 21 4,958 0 0 11930 NRG Energy, Inc. 6,106 6,106 2,709 1,871 0 0 1,526 0 0 0 0 0 0 101447 Entergy Gulf States, Inc. 6,106 7 5,984 1,036 244 0 320 434 0 3,950 0 0 0 112434 South Carolina Public Service Authority 5,879 5,793 0 4,429 0 1,111 0 229 0 19 6 127793 Southern Nuclear Operating Co. 5,818 5,818 5,818 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1,112	0	0	0	0	3,149	4,202	43	0	3,333	0	11,839		5 Florida Power Corp.	101395
104284 City Public Service Board of San Antonio 6,449	0	0	0	0	0	0	4,472	3,504	0	0	0	7,976		1 Southern Power Co.	11706551
101425 Entergy Louisiana, Inc. 6,179 6,179 1,200 0 0 0 0 1,526 0 0 0 0 0 119141 19530 NRG Energy, Inc. 6,106 6,106 6,106 7,709 1,871 0 0 1,526 0 0 0 0 0 0 0 1,526 0 0 0 0 0 1,526 10 0 0 0 1,526 10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0	0 0	0	0	2,227	0	904	78	0	3,400	0	6,609		6 Entergy Arkansas, Inc.	101516
119530 NRG Energy, Inc. 119530 Nather Energy Rushissispip, Inc. 119530 Nather Energy Rushissispip, Inc. 119530 Nather Energy, Inc. 1195	0	0 0	0	0	2,829	0	550	0	0	3,071	0	6,449	-,	4 City Public Service Board of San Antonio	104284
101447 Entergy Gulf States, Inc. 6,065	0	0 0	0	0	4,958	21	0	0	0	0	1,200	6,179	6,179	5 Entergy Louisiana, Inc.	101425
112434 South Carolina Public Service Authority 5,879 5,793 0 4,429 0 1,111 0 229 0 19 6 127793 Southern Nuclear Operating Co. 5,818 5,818 5,818 0 0 0 0 0 0 0 0 0 0 0 0 126320 South Carolina Electric & Gas Co. 5,798 5,025 1,000 2,072 0 190 1,634 130 0 0 0 5690978 NextEra Energy Resources, LLC 5,614 3,194 0 0 0 0 3,194 0 0 0 0 0 101217 Southwestern Electric Power Co. 5,591 5,591 0 2,953 0 332 480 0 1,826 0 0 100334 Tampa Electric Co. 5,216 5,216 0 1,885 0 1,030 2,254 0 0 0 6 0 0 1010263 Oglethorpe Power Corp. 3,783 2,933 0 0 0 2,790 0 382 785 0 0 0 0 0 100263 Oglethorpe Power Corp. 3,783 2,933 0 0 0 2,393 540 0 0 0 0 1010347 Southwestern Public Service Co. 3,697 3,697 0 2,216 0 2,790 0 1,807 1,812 0 0 0 0 1212756594 Cinergy Solutions, Inc. 3,619 3,619 0 0 0 1,807 1,812 0 0 0 0 100292 Mississipip Power Co. 3,458 3,458 0 1,051 0 144 2,064 0 200 0 0 127329 American National Power, Inc. 3,323 3,323 0 600 0 0 2,773 0 0 2,775 0 0 103356 Entergy Mississipip, Inc. 3,325 3,258 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0	0 0	0	0	0	0	1,526	0	0	1,871	2,709	6,106	.,	0 NRG Energy, Inc.	119530
127793 Southern Nuclear Operating Co. 5,818	0	0 0	0	0	3,950	0	434	320	0	244	1,036	5,984		7 Entergy Gulf States, Inc.	101447
126320 South Carolina Electric & Gas Co. 5,798	0	5 0	6	19	0	229	0	1,111	0	4,429	0	5,793	5,879 💆	4 South Carolina Public Service Authority	112434
5690978 NextEra Energy Resources, LLC 5,614	0	0 0	0	0	0	0	0	0	0	0	5,818	5,818	5,818	3 Southern Nuclear Operating Co.	127793
101217 Southwestern Electric Power Co. 5,591 5,591 0 2,953 0 332 480 0 1,826 0 0 1 1,826 0 0 1,0034 Tampa Electric Co. 5,216 5,216 0 1,885 0 1,030 2,254 0 0 0 6 0 4 116619 Jacksonville Electric Authority 3,957 3,957 0 2,790 0 382 785 0 0 0 0 0 0 1,00263 Oglethorpe Power Corp. 3,783 2,933 0 0 0 0 2,393 540 0 0 0 0 0 1,00347 Southwestern Public Service Co. 3,697 3,697 0 2,216 0 27 0 0 1,454 0 0 1 1,00264 Cinergy Solutions, Inc. 3,619 3,619 0 0 0 1,807 1,812 0 0 0 0 0 1,00264 Cinergy Solutions, Inc. 3,458 3,458 0 1,051 0 144 2,064 0 200 0 0 1,00264 Cinergy Mississippi Power Co. 3,323 3,323 0 600 0 0 2,723 0 0 0 0 0 1,0026 Cinergy Mississippi, Inc. 3,258 3,258 0 0 0 0 0 0 500 0 2,758 0 0 1,003619 Lower Colorado River Authority 3,232 2,955 0 1,690 0 180 0 0 0 1,085 0 0	0	0 0	0	0	0	130	1,634	190	0	2,072	1,000	5,025	5,798	0 South Carolina Electric & Gas Co.	126320
100334 Tampa Electric Co. 5,216	0	0 0	0	0	0	0	3,194	0	0	0	0	3,194	5,614	8 NextEra Energy Resources, LLC	5690978
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100263 Oglethorpe Power Corp. 3,783	0) 42	0	6	0	0	2,254	1,030	0	1,885	0	5,216		4 Tampa Electric Co.	100334
100347 Southwestern Public Service Co. 3,697 3,697 0 2,216 0 27 0 0 1,454 0 0 1212756594 Cinergy Solutions, Inc. 3,619 3,619 0 0 0 1,807 1,812 0 0 0 0 100292 Mississippi Power Co. 3,458 3,458 0 1,051 0 144 2,064 0 200 0 0 127329 American National Power, Inc. 3,323 3,323 0 600 0 0 2,723 0 0 0 0 103356 Entergy Mississippi, Inc. 3,258 3,258 0 0 0 0 500 0 2,758 0 0 103619 Lower Colorado River Authority 3,232 2,955 0 1,690 0 180 0 0 1,085 0 0	0	0 0	0	0	0	0	785	382	0	2,790	0	3,957	3,957	9 Jacksonville Electric Authority	116619
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	0	0	0	0	0	0	594	2,486	0	0	0	3,080		1 ArcLight Capital Partners, LLC	14445641
127181 Dow Chemical Co. 3,074 ^F 3,074 0 0 0 0 3,074 0 0 0	0	0	0	0	0	0	3,074	0	0	0	0	3,074	3,074	1 Dow Chemical Co.	127181

• 'Snowball' sampling

Climate-energy relevant boundary organizations:



Academic Centers

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Boundary organizations: "Organizations designed to facilitate collaboration and information flow between the research and public policy communities (Guston, 1999,



Some preliminary insights: Literature



- Available literature on is limited
 - Literature largely focuses on impacts on supply, with less discussion of generation, transmission, distribution
 - Reflects perception of climate change as a public sector issue?
- Hazards/impacts of interest are region- and sector-specific
 - Issues for the Southeast/Gulf Coast differ markedly from other U.S. and global regions
- Emphasis on interconnectedness of infrastructure
 - Generation \rightarrow distribution/transmission \rightarrow end use
 - Transportation is a critical enabling infrastructure
 - Depreciation/aging of existing infrastructure a key vulnerability
- Industry focused on both structural and non-structural responses
 - Structural: facility siting, retrofitting of technologies, modernization
 - Non-Structural: regulatory streamlining, design standards, cost sharing,

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Some preliminary insights: Stakeholders



The politics of climate influence the regional discourse

- Emphasis on "preparedness", "risk management", and "community resilience" rather than climate change adaptation
- Perceived differences between electricity/oil & gas sectors
- There are significant, unmet demands for knowledge
 - Climate change projections/prediction
 - Future policy development
 - Future energy markets, growth in service areas

Reflects the need for integrated assessment

- Recent extreme events are a laboratory for adaptation
 - Reveal vulnerabilities





Some preliminary insights: Stakeholders



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- Networks are critical for sharing knowledge and increasing resilience
 - Partnership can enhance credibility (e.g., Entergy/America's Wetlands)
 - Provides opportunity for leveraging resources (e.g., EPRI)
- Perception gap between stakeholders and researchers
 - Does 'adaptation' requires changes to planning beyond existing risk-management practices?
- Issue of stationarity (the 'new normal') and managing under ranges of uncertainty
- Stakeholder demand for subregional scale projections





Some preliminary insights for adaptation research & science



- Adaptation decisionmaking does not occur in a vacuum broader context matters in terms of how adaptation decisions are made
 - Actors respond to and manage multiple risks
 - Actions strongly influenced by regulators
 - Strong-emphasis on incremental adjustment to challenges and opportunities as they arise
- There are clear interactions between public and private adaptation
 - Regulators can expand or constrain the adaptation the solution space for the energy sector (e.g., extent to which companies can pass on costs)
 - Community resilience is dependent upon effective adaptation on the part of private entities that deliver key goods and services
 - Collaborative approaches among public/private actors are needed

More attention to the role of private entities is needed by adaptation researchers and practitioners

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Another view of an energy sector interview:



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